

FMC116/FMC112 User Manual



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1 Acronyms and related documents

1.1 Acronyms

ADC	Analog-to-Digital Converter
DDR	Double Data Rate
DSP	Digital Signal Processing
EPROM	Erasable Programmable Read-Only Memory
FBGA	Fineline Ball Grid Array
FMC	FPGA Mezzanine Card
FPGA	Field Programmable Gate Array
JTAG	Join Test Action Group
LED	Light Emitting Diode
LVTTTL	Low Voltage Transistor Logic level
LSB	Least Significant Bit(s)
LVDS	Low Voltage Differential Signaling
MGT	Multi-Gigabit Transceiver
MSB	Most Significant Bit(s)
PCB	Printed Circuit Board
PCI	Peripheral Component Interconnect
PCIe	PCI Express
PLL	Phase-Locked Loop
PMC	PCI Mezzanine Card
PSSR	Power Supply Rejection Ratio
QDR	Quadruple Data rate
SDRAM	Synchronous Dynamic Random Access memory
SRAM	Synchronous Random Access memory
TTL	Transistor Logic level
XMC	PCIe Mezzanine card

Table 1: Glossary

1.2 Related Documents

- FPGA Mezzanine Card (FMC) standard ANSI/VITA 57.1-2010
- Datasheet AD9517 Rev A, Analog Devices
- Datasheet LTC2175-14 Linear Technology
- Datasheet ADT7411 Rev B, Analog Devices

2 General description

The FMC116 is a 16-channel ADC FMC daughter card. The card provides sixteen 14-bit 125MSPS ADC channels which can be clocked by an internal clock source (optionally locked to an external reference) or an externally supplied sample clock. There is a trigger input and a trigger output for customized sampling control. A low-pin count variant is available offering 12 channels (FMC112). The FMC116/FMC112 daughter card is mechanically and electrically compliant to FMC standard (ANSI/VITA 57.1). The FMC116/FMC112 has a high-pin count connector, front panel I/O, and can be used in conduction-cooled environments.

The design is based on Linear Technology's quad channel 14-bit 125MSPS ADC with high-speed serial DDR LVDS outputs (2-lanes per channel). The analog signal input is DC-coupled connecting to a Samtec connector on the front panel.

The FMC116/FMC112 allows flexible control on sampling frequency through a serial communication bus (SPI). The card is also equipped with power supply and temperature monitoring and offers several power-down modes to switch off unused functions or protect the card from overheating.

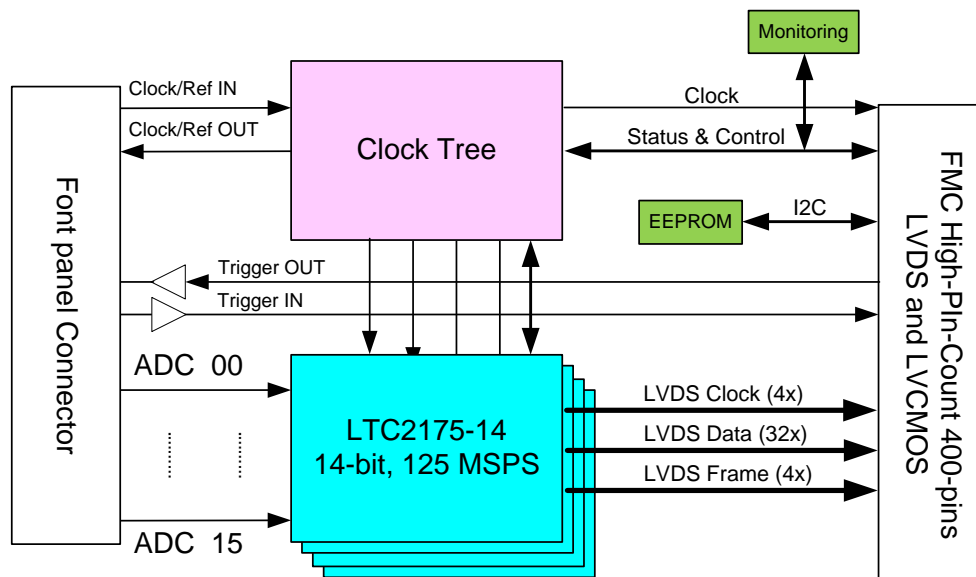


Figure 1: FMC116 block diagram

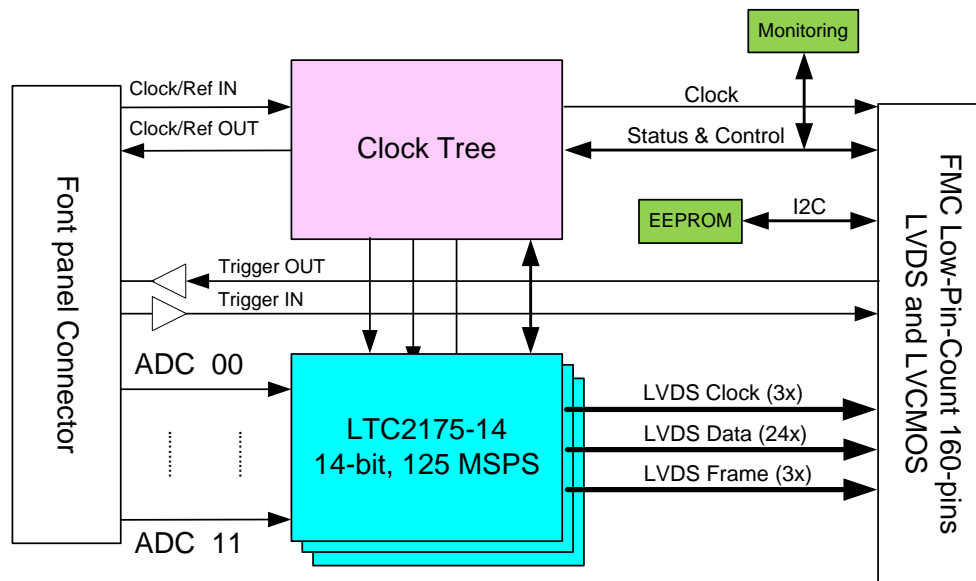


Figure 2: FMC112 block diagram

3 Installation

3.1 Requirements and handling instructions

- The FMC116/FMC112 daughter card must be installed on a carrier card compliant to the FMC standard.
- The FMC carrier card must either offer an LPC or HPC FMC site. Note that a LPC FMC site offers limited functionality (12 out of 16 channels).
- The carrier card can support VADJ/VIO_B voltage range of 1.65V to 3.3V for the FMC116, but typically VADJ will be 1.8V or 2.5V for LVDS operation.
- Prevent electrostatic discharges by observing ESD precautions when handling the card.

4 Design

4.1 Physical specifications

4.1.1 Board Dimensions

The FMC116/FMC112 card complies with the FMC standard known as ANSI/VITA 57.1. The card is a single-width, conduction-cooled mezzanine module (with region 1 and front panel I/O). The front area holds an edge-mounted Samtec connector (QSE-020-01-F-D-EM2) that might conflict with a front rib on a carrier card.

There are different mounting options for different cable ends:

- 1) For this option, an adapter PCB is mounted on the FMC. This enables the cable to be mated while the FMC is installed on a carrier. All signals, including clock and trigger signal, are mapped on a single connector. This is the default factory configuration.

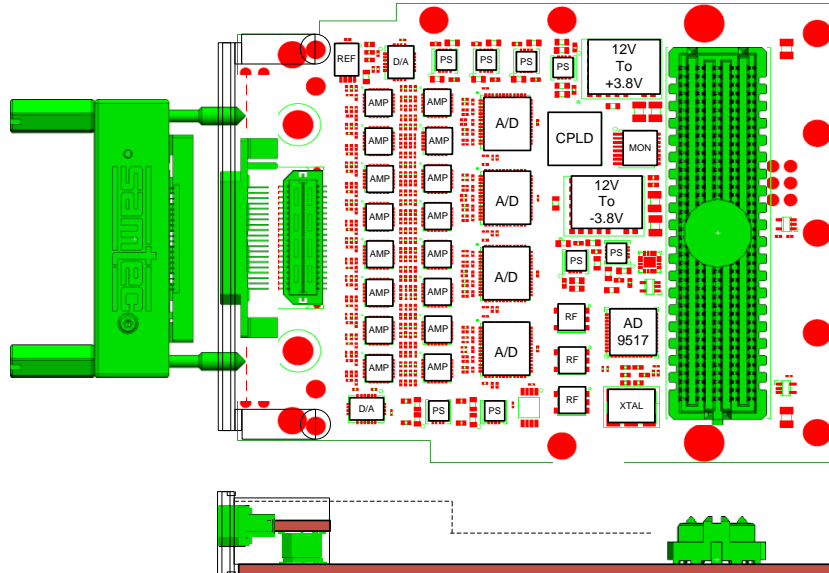


Figure 3 : FMC116/FMC112 dimensions, mounting option 1

A SMA breakout solution is available for the FMC116/FMC112. It gives access to the signals on female SMA connectors. The breakout option can be specified in the order number.

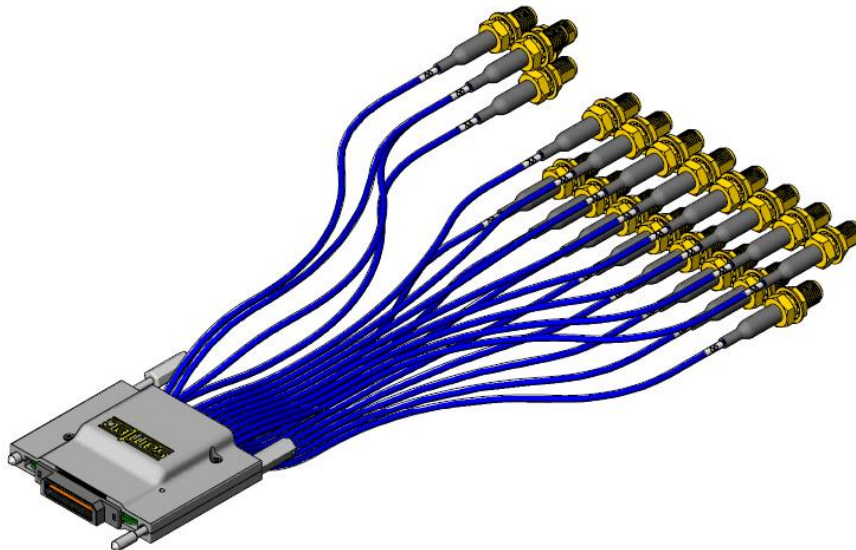


Figure 4. SMA breakout cable

- 2) The second mounting option is a cable is directly mounted on the FMC. The cable needs to be mounted prior installing the FMC on the carrier. The part number of the connector on the FMC116/FMC112 is QSE-020-01-F-D-A-K.

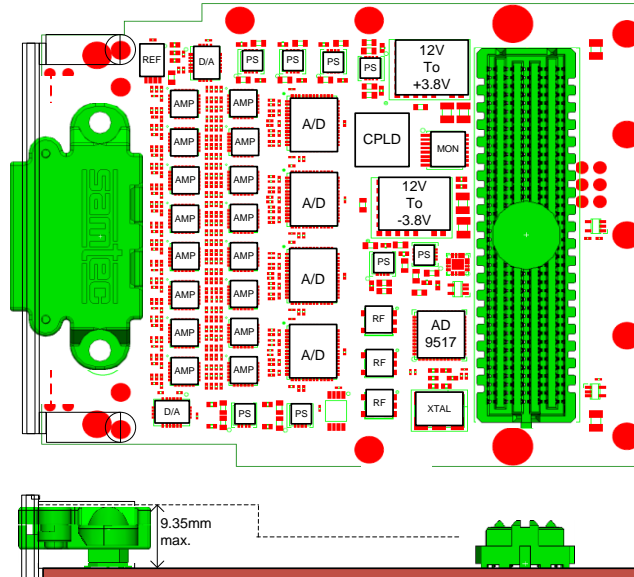


Figure 5: FMC116/FMC112 dimensions, mounting option 2

4.1.2 Front panel

One Samtec connector (QSE-020) for the 16 analog channels is available from the front panel. Note that the cable labels are numbered from 1 to 16, but the captured ADC data is saved from 0 to 15.

Side 1			Cable	Side 2			Cable
Pin	Signal	Label		Pin	Signal	Label	
1	CH 08	CH09		2	GND		
3	GND			4	CH 09	CH10	
5	CH 10	CH11		6	GND		
7	GND			8	CH 11	CH12	
9	CH 04	CH05		10	GND		
11	GND			12	CH 05	CH06	
13	CH 06	CH07		14	GND		
15	GND			16	CH 07	CH08	
17	CH 00	CH01		18	GND		
19	GND			20	CH 01	CH02	
21	CH 02	CH03		22	GND		
23	GND			24	CH 03	CH04	

25	CH 12*	CH13		26	GND	
27	GND			28	CH 13*	CH14
29	CH 14*	CH15		30	GND	
31	GND			32	CH 15*	CH16
33	GND			34	GND	
35	CLOCK IN	CI		36	GND	
37	GND			38	TRIGGER IN	TI
39	CLOCK OUT	CO		40	TRIGGER OUT	TO

Table 2: Analog input connector pin-out

* Channels 12 to 15 are not available on LPC carrier cards.

4.1.1 Clock / Trigger connector option

Optionally, four dedicated SSMC connectors can be placed for the following signals:

- CLOCK IN
- CLOCK OUT
- TRIGGER IN
- TRIGGER OUT

Whether those signals are connected to the SSMC or the QSE-020 connector is determined by a 0R build option. The SSMC connectors are not placed by default, and all signals connect to the QSE-020 connector. Please contact the factory for other options.

Note that the SSMC connectors will be placed on the opposite side of the QSE-020 connector. The customer should verify whether this is acceptable in their environment, since it breaches the mechanical constraints of the FMC standard.



Figure 6: SSMC connector option

4.1.2 LVDS mode

All data and clock signals to the carrier are LVDS pairs. The VADJ voltage supplied to the FMC116 can range between 1.65V and 3.3V, but typically VADJ will be 1.8V or 2.5V for LVDS operation. VIO_B is connected to VADJ. The A/D converters operate in LVDS mode, supplying an LVDS clock and DDR LVDS data/frame signals. All other status and control signals, like serial communication busses, operate at LVCMOS level ($V_{OH} = VADJ$).

4.1.1 EEPROM

The FMC116/FMC112 card carries a small serial EEPROM which is accessible from the carrier card through the I²C bus. The EEPROM is powered by 3P3VAUX. The standby current is only 0.01μA when SCL and SDA are kept at 3P3VAUX level. These signals may also be left floating since pull-up resistors are present on the FMC116/FMC112.

The EEPROM is factory programmed with information recommended in the FMC standard. The EEPROM is therefore available as read-only memory on the FMC116/FMC112 (write protected).

4.1.1 Stacked FMC

The FMC connector as defined in ANSI/VITA 57.1 is referred as the top FMC connector. The FMC116/FMC112 can be used in a stacked environment when the bottom FMC connector is mounted. The following connections are available between the top and bottom FMC connector:

- All gigabit data signals (DP[0..9]_M2C_P/N, DP[0..9]_C2M_P/N).
- All gigabit reference clocks (GBTCLK[0..1]_M2C_P/N).
- RES0
- 3P3VAUX, 3P3V, 12P0V, VADJ

The bottom FMC connector is not mounted on factory default boards.

4.1.2 JTAG

The FMC116/FMC112 has a CPLD device in the JTAG chain.

4.2 Main characteristics

Analog inputs	
Number of channels	16 on FMC116 12 on FMC112
Channel resolution	14-bit
Input voltage range	2Vp-p (10 dBm, inverted)
Input impedance	50Ω
Analog input bandwidth	DC to 62.5MHz
SNR	68 dBFS typ.
Crosstalk	55dB @ 32MHz typ.
External sampling clock input	
Input Level	-10dBm to +7dBm
Input impedance	50Ω

Input bandwidth	Input RF transformer: 3 MHz to 800 MHz. (AC-coupled)
External reference clock input	
Input Level	-10dBm to +7dBm
Input impedance	50Ω
Input bandwidth	Input RF transformer: 3 MHz to 800 MHz. (AC-coupled)
External reference clock output	
Output Level	800mVp-p into 50Ω typical
External Trigger input	
Format	LVTLL/LVCMOS
Threshold	Logic '0' (input low) → max 1.25V Logic '1' (input high) → min 1.25V
Frequency range	Up to 125 MHz
ADC Output	
Output data width	2-pair DDR LVDS per channel Frequency 3.5 times the sample frequency
Data Format	Offset binary or 2's complement
Sampling Frequency Range	5 MHz to 125 MHz.
FMC connector type	HPC (ASP-134488-01)
Internal sampling clock	
Format	LVPECL
Frequency Range	up to 125MHz (Software programmable)

Table 3 : FMC116/FMC112 daughter card main characteristics

4.3 Analog input channels

The analog input signals are connected to the FMC116/FMC112 via the Samtec connector on the front panel. The Samtec connector alternates channels and ground pins to minimize crosstalk between channels.

4.3.1 ADC driver

The input circuit is DC-coupled using Analog Devices ADA4938 ADC driver. The gain (G) is set to one giving maximum input bandwidth (BW). As a build option, larger gain can be realized, but the bandwidth will be reduced accordingly (consult factory for more details). Note that that a polarity twist between the op amp and the ADC results in an inverted input signal.

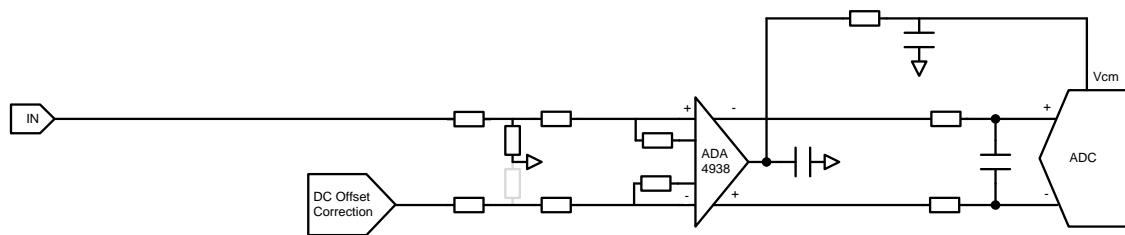


Figure 7: ADC input circuit

4.3.2 DC offset correction

DC offset correction is enabled through a small 16-bit DAC device. An op amp is used as a buffer and to make a bi-polar output on the DAC. The DAC uses an external reference voltage V_{ref} . The DAC output swings from 0V to $2 \cdot V_{ref}$. A resistor divider is used for a reduced swing of 0V to V_{ref} . The output of the op amp has a swing from $-V_{ref}$ to $+V_{ref}$. The granularity of the DC offset correction depends on the DAC resolution and the voltage reference. For a 16-bit DAC device with 1.25V reference each step corresponds to approximately $40\mu V$.

The circuit depicted in Figure 8 is implemented for each channel, using two octal DAC devices (LTC2656), eight dual op amps (ADA4932-2), and one voltage reference (LTC6655-1.25).

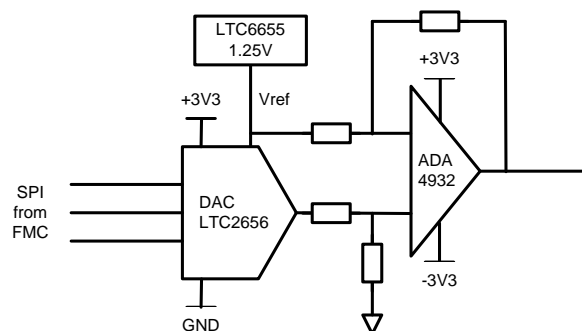


Figure 8: DC offset correction circuit.

4.4 External trigger signals

4.4.1 External trigger input

The input is single-ended and DC-coupled with an input impedance of approximately $2.5k\Omega$. The input threshold is approximately 1.25V. An LVTTTL signal is recommended.

4.4.2 External trigger output

The signal CTRL<7> from the FMC connector is routed to the external trigger output through a SN74LVC1G126 buffer. The buffer is always enabled and powered by 3.3V. The trigger output is LVTTTL level.

NOTE: The external trigger output can only work with a VADJ level of 2.5V (CTRL7 requires $V_{ih\ min} = 2V$).

4.5 Clock tree

4.5.1 Architecture

The FMC116/FMC112 card offers a clock architecture that combines flexibility and high performance. Components have been chosen to minimize jitter and phase noise and to improve the data conversion performance. The user may choose to use an external or an internal sampling clock.

The AD9517-3 PLL and clock distribution device is the base of the clock tree. The external clock input is routed to a RF switch, connecting either to the reference input on the AD9517-3 (REFIN) or to the clock input on the AD9517-3 (CLK). The clock input can be connected directly to the distribution section of the AD9517-3.

The internal VCO of the AD9517-3 is used. A reference clock on REFIN is required to tune the VCO to a certain frequency. An onboard oscillator can be enabled if no external reference is connected. The onboard oscillator is connected in parallel with the clock input behind the RF transformer. **To avoid interference there should be no signal applied to clock input when internal reference is used (selected by CLKSRC_SEL1).**

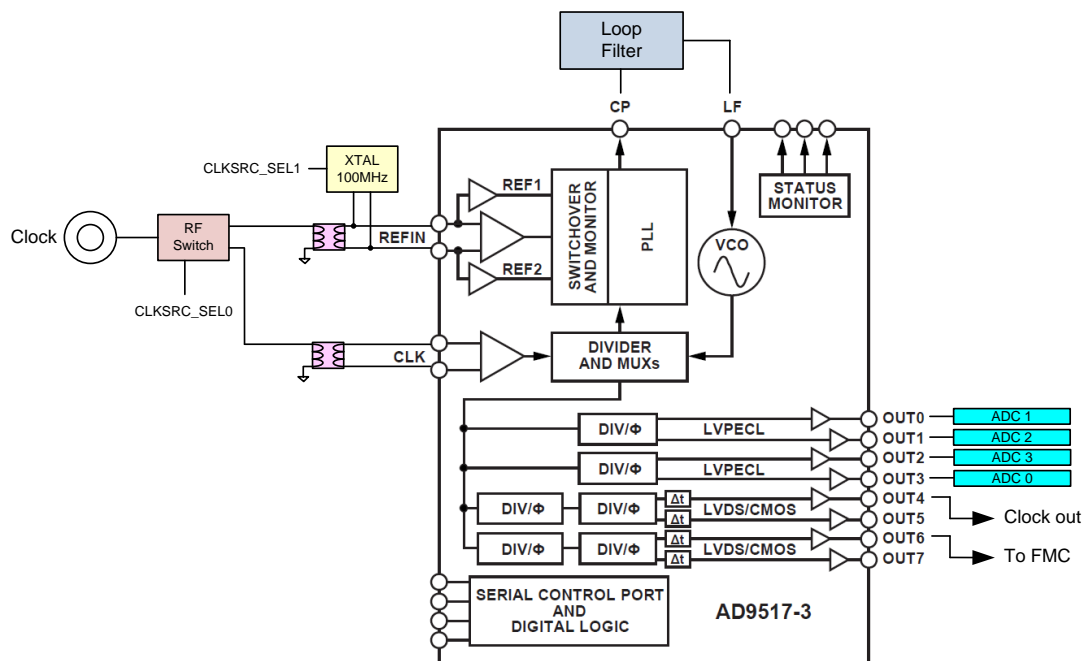


Figure 9: Clock tree architecture

The AD9517-3 has four LVPECL outputs (OUT0 to OUT3) which are used for clocking the ADC devices. The other four clock outputs can be either programmed as LVDS or LVCMOS33. These outputs have the ability to enable a programmable delay: one is connected to the FMC connector for test and monitoring purposes while the other connects to the clock output on the front panel.

4.5.1 External clock input

There is one clock input on the front panel that can serve as a sampling clock input or as reference clock input if the internal clock with external reference is desired. An RF switch

(ADG918) connects the external clock input to either the reference input (REFIN) or the clock input (CLK) of the AD9517.

Note: When the internal clock is enabled and there is no need for an external reference, it is highly recommended to leave the clock input unconnected to prevent interference with the internal clock.

4.5.2 External clock output

The external clock output is connected through a RF transformer (TC2-1T). Setting up the AD9517 for LVDS outputs is recommended. The RF transformer is used for differential to single-ended conversion and impedance matching. A 50Ω load on the clock output is expected.

4.5.3 PLL design

The PLL functionality of the AD9517-3 is used to operate from an internal sampling clock. To enable flexibility in frequency selection while maintaining high performance, the internal VCO is used. The default loop filter is designed for a phase detector frequency of 10MHz, loop bandwidth of 10 kHz, phase margin of 45 degrees, and a charge pump of 4.8mA.

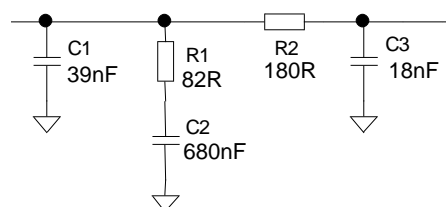


Figure 10: VCO loop filter design

Lower phase detector frequencies might be required to achieve the required output clock frequency (phase detector frequency equals the VCO tuning step size). Whether the loop filter design still works for other configurations should be investigated case-by-case.

4.6 Power supply

Power is supplied to the FMC116/FMC112 card through the FMC connector. The power provided by the carrier card can be noisy. Special care is taken with the power supply generation on the FMC116 card to minimize the effect of power supply noise on clock generation and data conversion.

The analog and digital +1.8V for the ADC devices are derived directly from the +3.3V plane in a linear way. Each analog supply uses its own low-noise, high-PSRR, linear regulator to isolate power supply noise between ADCs.

Analog (clock) and bipolar 3.3V power is derived from +12V in two steps for maximum efficiency. The first step uses switched regulators to generate a -3.8V and +3.8V power rail. From this power rail, each analog supply is derived with separate low-dropout, low-noise, high-PSRR, and linear regulators. The regulators have sufficient copper area and thermal vias to dissipate the heat in combination with proper airflow (see section 6.2 Cooling).

Worst case power consumption:

15.4 W

Typical power consumption:

12.0 W

Power plane	Typical		Maximum
	DC – High Performance	DC – Low Power	Maximum
VADJ	300mA + I _{VIO_B}	300mA + I _{VIO_B}	500mA + I _{VIO_B}
3P3V	1328mA	1328mA	1436mA
12P0V	630mA	289mA	885mA
3P3VAUX (Operating)	0.1 mA	0.1 mA	3 mA
3P3VAUX (Standby)	0.01 μ A	0.01 μ A	1 μ A

Table 4: Typical/Maximum current drawn from FMC carrier card

5 Controlling the FMC116/FMC112

A small CPLD is implemented on the board to control the FMC116/FMC112 through a minimal amount of connections on the FMC connector. This allows for a maximum amount of A/D channels mapped to the LPC connections.

The FMC116/FMC112 maps control signals and 12 A/D channels to the LPC connections. The remaining four A/D channels are mapped to HPC connections. If the FMC is used on a LPC carrier, 12 of the 16 A/D channels will be available (FMC112).

5.1 Control Architecture

The FMC needs to be controlled from the carrier hardware through a single SPI communication bus. The SPI communication bus is connected to a CPLD which has the following tasks:

- Distribute SPI access from the carrier hardware to the local devices:
 - 4x LTC2175 (A/D converters)
 - 1x AD9517 (Clock Tree)
 - 2x LTC2656 (D/A converters)
- Select clock source based on a SPI command from the carrier hardware (CLKSRC_SEL).
- Generate SPI reset for AD9517 (CLK_N_RESET)
- Collect local status signals and store them in a register which can be accessed from the carrier hardware.
- Drive a LED according to the level of the status signals.

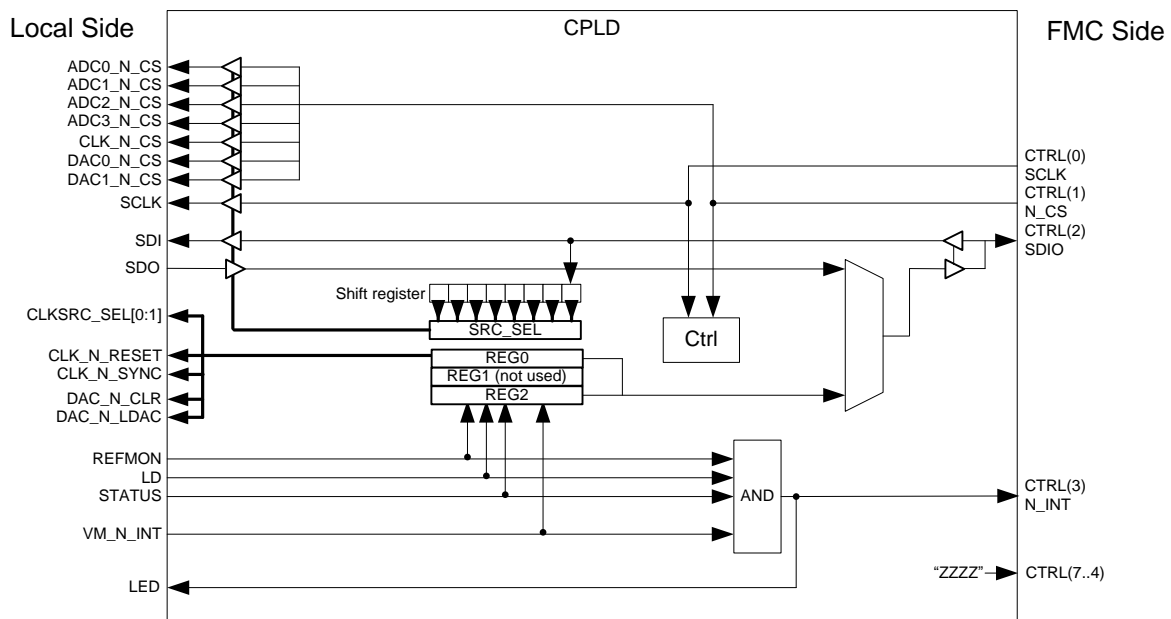


Figure 11: CPLD architecture

Notes:

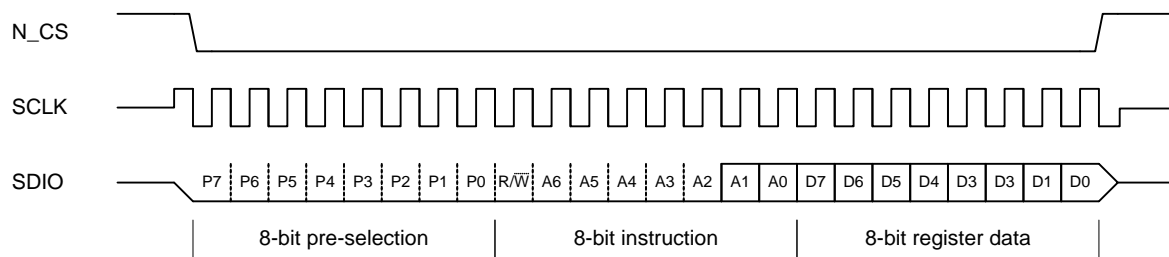
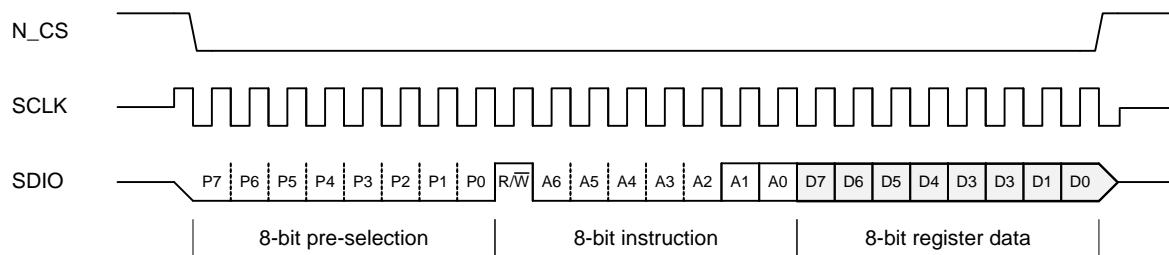
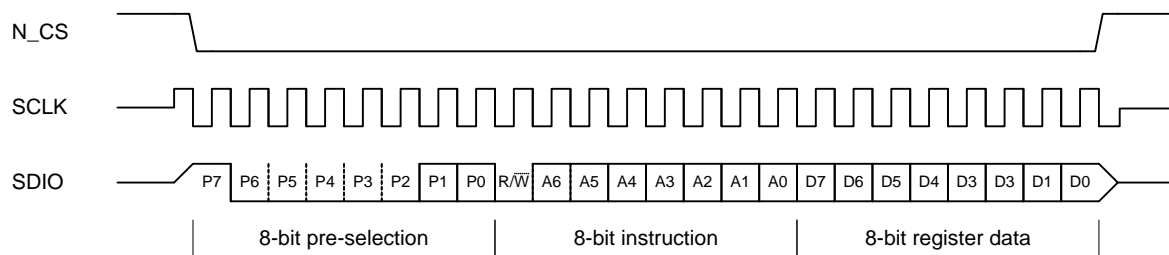
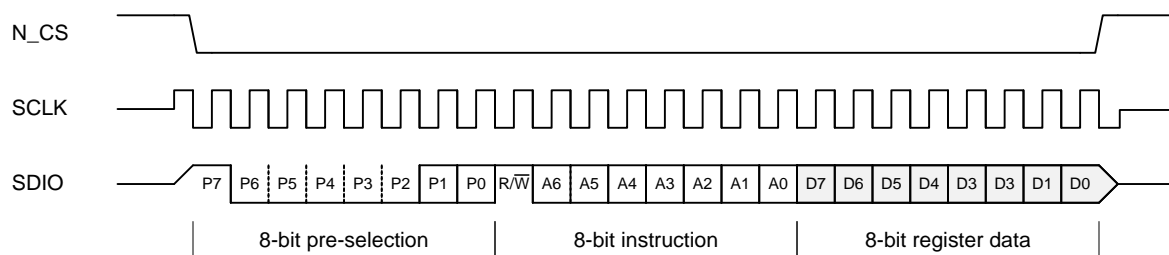
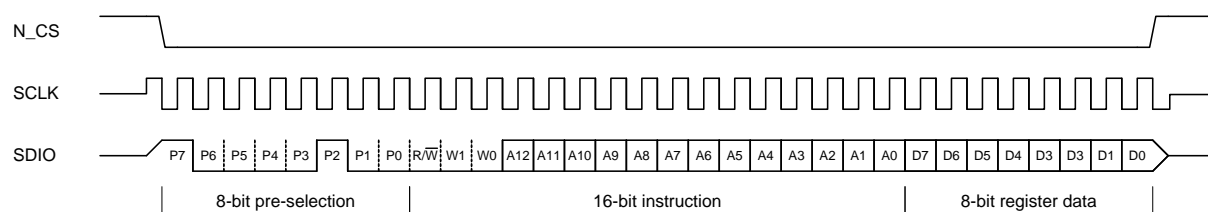
- SDO from the LTC2656 devices are not connected.
- N_PD on the AD9517 is not connected.

5.2 SPI Programming

The SPI programmable devices on the FMC116/FMC112 can be accessed as described in their datasheet, but each SPI communication cycle needs to be preceded with a preselection byte. The preselection byte is used by the CPLD to forward the SPI command to the right destination (through CS# pins). The preselection bytes are defined as follows:

-	CPLD		0x00	
-	LTC2175	#1	0x80	(A/D channels 00 to 03)
-	LTC2175	#2	0x81	(A/D channels 04 to 07)
-	LTC2175	#3	0x82	(A/D channels 08 to 11)
-	LTC2175	#4	0x83	(A/D channels 12 to 15)
-	AD9517		0x84	
-	LTC2656	#1	0x85	
-	LTC2656	#2	0x86	

The CLPD has three internal registers which are described in **Appendix B CPLD Register map**. The registers of the other devices are transparently mapped.

**Figure 12: Write instruction to CPLD registers A1:A0****Figure 13: Read instruction to CPLD registers A1:A0****Figure 14: Write instruction to LTC2175 registers A4:A0****Figure 15: Read instruction to LTC2175 registers A4:A0****Figure 16: Write instruction to AD9517 registers A12:A0**

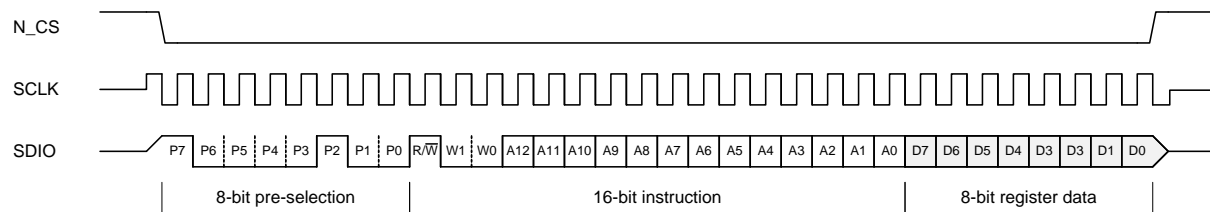


Figure 17: Read instruction to AD9517 registers A12:A0

Good knowledge of the internal structure and communication protocol of relevant onboard devices is required for controlling the FMC116/FMC112. This document only gives guidelines for programming the devices. Please refer to the datasheets mentioned in the Related Documents section of this user manual for detailed information. 4DSP may also be contacted for programming support.

5.3 Guidelines for controlling the clock tree

Apart from enabling the internal reference the whole clock tree is controlled by programming the AD9517 device through a serial communication bus. The following guidelines should be taken into account:

- 1) The internal reference is enabled by CLKSRC_SEL1 driven from the CPLD. The internal reference should only be enabled if the internal clock is used and no external reference is applied.
- 2) The communication bus should be used in bidirectional mode; thus, using SDIO as serial data input and output.
- 3) It is recommended to disable the unused clock outputs.
- 4) It is recommended to disable PLL functions on the AD9517 when an external sampling clock is applied.
- 5) Although the AD9517 provides separate dividers on each clock output, it is not recommended to use different divider settings.
- 6) Lower phase detector frequencies may be used to increase flexibility on the output frequency. The stability of the PLL is not guaranteed in all cases.
- 7) If multiple cards are cascaded by means of connecting the clock output to the clock input of the next card, the programmable delay on the clock output may be used to compensate for the propagation delay between cards.

5.4 Guidelines for controlling the ADCs

Controlling the ADCs enables advanced control of the digitizing process. The ADC devices allows for serial and parallel programming. On the FMC116/FMC112 the PAR/SER# pins of the ADC are tied together and driven low by the CPLD, forcing the devices in serial programming mode.

5.5 Guidelines for ADC offset control

Offset control is available per individual ADC channel. The following table shows the ADC channel controlled by each DAC output.

LTC2656 Channel	LTC2656 Device #1	LTC2656 Device #2
VOUT_A	A/D 08	A/D 00
VOUT_B	A/D 09	A/D 01
VOUT_C	A/D 10	A/D 02
VOUT_D	A/D 11	A/D 03
VOUT_E	A/D 04	A/D 12
VOUT_F	A/D 05	A/D 13
VOUT_G	A/D 06	A/D 14
VOUT_H	A/D 07	A/D 15

Table 5: Offset control

5.6 Guidelines for controlling onboard monitoring

The FMC116/FMC112 has one ADT7411 device for monitoring several power supply voltages on the board as well as temperature. The devices can be programmed and read out through the I2C interface.

- 1) The measured value on +3.3V and rails must be multiplied by two to get the actual level.
- 2) The negative supply (-3.3V Analog) is connected with a resistive divider to Vdd. Therefore the formula from the Table 6 should be used.
- 3) Continuously operating the I2C bus might interfere with the conversion process and result in signal distortion. It is recommended to program the minimum and maximum limits in the monitoring devices, and only read from the device when the interrupt line is asserted.

Parameter:	Device 1 address 1001 000	Formula
On-chip temperature		
On-chip AIN0 (V _{DD})	+3.3V	VDD
External AIN1	+1.8V #2	AIN1
External AIN2	+1.8V #3	AIN2
External AIN3	1.8V Digital	AIN3
External AIN4	-3.3V Analog	5.7 AIN4 – 4.7 * VDD
External AIN5	+1.8V #1	AIN5
External AIN6	+1.8V #0	AIN6
External AIN7	+3.3V Clock	AIN7 * 2
External AIN8	+3.3V Analog	AIN8 * 2

Table 6: Temperature and voltage parameters

6 Environment

6.1 Temperature

Operating temperature

- -40°C to +85°C (Industrial)

Storage temperature:

- -40°C to +120°C

6.2 Cooling

Two different types of cooling will be available for the FMC116/FMC112.

6.2.1 Convection cooling

The air flow provided by the chassis fans the FMC116/FMC112 is enclosed in will dissipate the heat generated by the onboard components. A minimum airflow of 300 LFM is recommended.

For standalone operations (such as on a Xilinx development kit), it is highly recommended to blow air across the FMC to ensure that the temperature of the devices is within the allowed range. 4DSP's warranty does not cover boards on which the maximum allowed temperature has been exceeded.

6.2.1 Conduction cooling

In demanding environments, the ambient temperature inside a chassis could be close to the operating temperature defined in this document. It is very likely that in these conditions the

junction temperature of power consuming devices will exceed the operating conditions recommended by the devices manufacturers (mostly +85°C).

The FMC116/FMC112 is designed for maximum heat transfer to conduction-cooled ribs. A customized cooling frame that connects directly to the surface of the A/D devices is allowed. This conduction-cooling mechanism should be applied in combination with proper chassis cooling. Contact 4DSP for detailed mechanical information.

7 Safety

This module presents no hazard to the user.

8 EMC

This module is designed to operate within an enclosed host system built to provide EMC shielding. Operation within the EU EMC guidelines is not guaranteed unless it is installed within an adequate host system. This module is protected from damage by fast voltage transients originating from outside the host system which may be introduced through the system.

9 Warranty

	<i>Hardware</i>	<i>Software/Firmware</i>
Basic Warranty (included)	1 Year from Date of Shipment	90 Days from Date of Shipment
Extended Warranty (optional)	2 Years from Date of Shipment	1 Year from Date of Shipment

Appendix A Pin-out FMC116/FMC112

Table 7: FMC116 pin-out

AV57.1	HPC Pin	FMC116 Signal	AV57.1	HPC Pin	FMC116 Signal	AV57.1	HPC Pin	FMC116 Signal
CLK0_M2C_N	H5	CLK_TO_FPGA_N	HA00_N_CC	F5	DCO_N<3>	HB00_N_CC	K26	N.C.
CLK0_M2C_P	H4	CLK_TO_FPGA_P	HA00_P_CC	F4	DCO_P<3>	HB00_P_CC	K25	N.C.
CLK1_M2C_N	G3	EXT_TRIGGER_N	HA01_N_CC	E3	OUTA_N<15>	HB01_N	J25	N.C.
CLK1_M2C_P	G2	EXT_TRIGGER_P	HA01_P_CC	E2	OUTA_P<15>	HB01_P	J24	N.C.
CLK2_BIDIR_N	K5	N.C.	HA02_N	K8	OUTB_N<15>	HB02_N	F23	N.C.
CLK2_BIDIR_P	K4	N.C.	HA02_P	K7	OUTB_P<15>	HB02_P	F22	N.C.
CLK3_BIDIR_N	J3	N.C.	HA03_N	J7	OUTA_N<14>	HB03_N	E22	N.C.
CLK3_BIDIR_P	J2	N.C.	HA03_P	J6	OUTA_P<14>	HB03_P	E21	N.C.
LA00_N_CC	G7	DCO_N<0>	HA04_N	F8	OUTB_N<14>	HB04_N	F26	N.C.
LA00_P_CC	G6	DCO_P<0>	HA04_P	F7	OUTB_P<14>	HB04_P	F25	N.C.
LA01_N_CC	D9	DCO_N<1>	HA05_N	E7	FRAME_N<3>	HB05_N	E25	N.C.
LA01_P_CC	D8	DCO_P<1>	HA05_P	E6	FRAME_P<3>	HB05_P	E24	N.C.
LA02_N	H8	OUTA_N<3>	HA06_N	K11	OUTA_N<13>	HB06_N_CC	K29	N.C.
LA02_P	H7	OUTA_P<3>	HA06_P	K10	OUTA_P<13>	HB06_P_CC	K28	N.C.
LA03_N	G10	OUTB_N<3>	HA07_N	J10	OUTB_N<13>	HB07_N	J28	N.C.
LA03_P	G9	OUTB_P<3>	HA07_P	J9	OUTB_P<13>	HB07_P	J27	N.C.
LA04_N	H11	OUTA_N<2>	HA08_N	F11	OUTA_N<12>	HB08_N	F29	N.C.
LA04_P	H10	OUTA_P<2>	HA08_P	F10	OUTA_P<12>	HB08_P	F28	N.C.
LA05_N	D12	OUTB_N<2>	HA09_N	E10	OUTB_N<12>	HB09_N	E28	N.C.
LA05_P	D11	OUTB_P<2>	HA09_P	E9	OUTB_P<12>	HB09_P	E27	N.C.
LA06_N	C11	FRAME_N<0>	HA10_N	K14	N.C.	HB10_N	K32	N.C.
LA06_P	C10	FRAME_P<0>	HA10_P	K13	N.C.	HB10_P	K31	N.C.
LA07_N	H14	OUTA_N<1>	HA11_N	J13	N.C.	HB11_N	J31	N.C.
LA07_P	H13	OUTA_P<1>	HA11_P	J12	N.C.	HB11_P	J30	N.C.
LA08_N	G13	OUTB_N<1>	HA12_N	F14	N.C.	HB12_N	F32	N.C.
LA08_P	G12	OUTB_P<1>	HA12_P	F13	N.C.	HB12_P	F31	N.C.
LA09_N	D15	OUTA_N<0>	HA13_N	E13	N.C.	HB13_N	E31	N.C.
LA09_P	D14	OUTA_P<0>	HA13_P	E12	N.C.	HB13_P	E30	N.C.
LA10_N	C15	OUTB_N<0>	HA14_N	J16	N.C.	HB14_N	K35	N.C.
LA10_P	C14	OUTB_P<0>	HA14_P	J15	N.C.	HB14_P	K34	N.C.
LA11_N	H17	OUTA_N<7>	HA15_N	F17	N.C.	HB15_N	J34	N.C.
LA11_P	H16	OUTA_P<7>	HA15_P	F16	N.C.	HB15_P	J33	N.C.
LA12_N	G16	OUTB_N<7>	HA16_N	E16	N.C.	HB16_N	F35	N.C.
LA12_P	G15	OUTB_P<7>	HA16_P	E15	N.C.	HB16_P	F34	N.C.
LA13_N	D18	OUTA_N<6>	HA17_N_CC	K17	N.C.	HB17_N_CC	K38	N.C.
LA13_P	D17	OUTA_P<6>	HA17_P_CC	K16	N.C.	HB17_P_CC	K37	N.C.
LA14_N	C19	OUTB_N<6>	HA18_N	J19	N.C.	HB18_N	J37	N.C.
LA14_P	C18	OUTB_P<6>	HA18_P	J18	N.C.	HB18_P	J36	N.C.
LA15_N	H20	OUTA_N<5>	HA19_N	F20	N.C.	HB19_N	E34	N.C.
LA15_P	H19	OUTA_P<5>	HA19_P	F19	N.C.	HB19_P	E33	N.C.
LA16_N	G19	OUTB_N<5>	HA20_N	E19	N.C.	HB20_N	F38	N.C.
LA16_P	G18	OUTB_P<5>	HA20_P	E18	N.C.	HB20_P	F37	N.C.

LA17_N_CC	D21	DCO_N<2>	HA21_N	K20	N.C.	HB21_N	E37	N.C.
LA17_P_CC	D20	DCO_P<2>	HA21_P	K19	N.C.	HB21_P	E36	N.C.
LA18_N_CC	C23	FRAME_N<1>	HA22_N	J22	N.C.			
LA18_P_CC	C22	FRAME_P<1>	HA22_P	J21	N.C.			
LA19_N	H23	OUTA_N<4>	HA23_N	K23	N.C.			
LA19_P	H22	OUTA_P<4>	HA23_P	K22	N.C.			
LA20_N	G22	OUTB_N<4>						
LA20_P	G21	OUTB_P<4>						
LA21_N	H26	OUTA_N<11>						
LA21_P	H25	OUTA_P<11>						
LA22_N	G25	OUTB_N<11>						
LA22_P	G24	OUTB_P<11>						
LA23_N	D24	OUTA_N<10>						
LA23_P	D23	OUTA_P<10>						
LA24_N	H29	OUTB_N<10>						
LA24_P	H28	OUTB_P<10>						
LA25_N	G28	FRAME_N<2>						
LA25_P	G27	FRAME_P<2>						
LA26_N	D27	OUTA_N<9>						
LA26_P	D26	OUTA_P<9>						
LA27_N	C27	OUTB_N<9>						
LA27_P	C26	OUTB_P<9>						
LA28_N	H32	OUTA_N<8>						
LA28_P	H31	OUTA_P<8>						
LA29_N	G31	OUTB_N<8>						
LA29_P	G30	OUTB_P<8>						
LA30_N	H35	CTRL<1>						
LA30_P	H34	CTRL<0>						
LA31_N	G34	CTRL<3>						
LA31_P	G33	CTRL<2>						
LA32_N	H38	CTRL<5>				PG_C2M	D1	PG_C2M
LA32_P	H37	CTRL<4>				PG_M2C	F1	PG_M2C
LA33_N	G37	CTRL<7>				I2C_SCL	C30	I2C_SCL
LA33_P	G36	CTRL<6>				I2C_SDA	C31	I2C_SDA

Table 8: FMC112 pin-out

AV57.1	LPC Pin	FMC112 Signal	AV57.1	LPC Pin	FMC112 Signal	AV57.1	LPC Pin	FMC112 Signal
CLK0_M2C_N	H5	CLK_TO_FPGA_N	HA00_N_CC	F5	N.C.	HB00_N_CC	K26	N.C.
CLK0_M2C_P	H4	CLK_TO_FPGA_P	HA00_P_CC	F4	N.C.	HB00_P_CC	K25	N.C.
CLK1_M2C_N	G3	EXT_TRIGGER_N	HA01_N_CC	E3	N.C.	HB01_N	J25	N.C.
CLK1_M2C_P	G2	EXT_TRIGGER_P	HA01_P_CC	E2	N.C.	HB01_P	J24	N.C.
CLK2_BIDIR_N	K5	N.C.	HA02_N	K8	N.C.	HB02_N	F23	N.C.
CLK2_BIDIR_P	K4	N.C.	HA02_P	K7	N.C.	HB02_P	F22	N.C.
CLK3_BIDIR_N	J3	N.C.	HA03_N	J7	N.C.	HB03_N	E22	N.C.
CLK3_BIDIR_P	J2	N.C.	HA03_P	J6	N.C.	HB03_P	E21	N.C.
LA00_N_CC	G7	DCO_N<0>	HA04_N	F8	N.C.	HB04_N	F26	N.C.
LA00_P_CC	G6	DCO_P<0>	HA04_P	F7	N.C.	HB04_P	F25	N.C.

LA01_N_CC	D9	DCO_N<1>	HA05_N	E7	N.C.	HB05_N	E25	N.C.
LA01_P_CC	D8	DCO_P<1>	HA05_P	E6	N.C.	HB05_P	E24	N.C.
LA02_N	H8	OUTA_N<3>	HA06_N	K11	N.C.	HB06_N_CC	K29	N.C.
LA02_P	H7	OUTA_P<3>	HA06_P	K10	N.C.	HB06_P_CC	K28	N.C.
LA03_N	G10	OUTB_N<3>	HA07_N	J10	N.C.	HB07_N	J28	N.C.
LA03_P	G9	OUTB_P<3>	HA07_P	J9	N.C.	HB07_P	J27	N.C.
LA04_N	H11	OUTA_N<2>	HA08_N	F11	N.C.	HB08_N	F29	N.C.
LA04_P	H10	OUTA_P<2>	HA08_P	F10	N.C.	HB08_P	F28	N.C.
LA05_N	D12	OUTB_N<2>	HA09_N	E10	N.C.	HB09_N	E28	N.C.
LA05_P	D11	OUTB_P<2>	HA09_P	E9	N.C.	HB09_P	E27	N.C.
LA06_N	C11	FRAME_N<0>	HA10_N	K14	N.C.	HB10_N	K32	N.C.
LA06_P	C10	FRAME_P<0>	HA10_P	K13	N.C.	HB10_P	K31	N.C.
LA07_N	H14	OUTA_N<1>	HA11_N	J13	N.C.	HB11_N	J31	N.C.
LA07_P	H13	OUTA_P<1>	HA11_P	J12	N.C.	HB11_P	J30	N.C.
LA08_N	G13	OUTB_N<1>	HA12_N	F14	N.C.	HB12_N	F32	N.C.
LA08_P	G12	OUTB_P<1>	HA12_P	F13	N.C.	HB12_P	F31	N.C.
LA09_N	D15	OUTA_N<0>	HA13_N	E13	N.C.	HB13_N	E31	N.C.
LA09_P	D14	OUTA_P<0>	HA13_P	E12	N.C.	HB13_P	E30	N.C.
LA10_N	C15	OUTB_N<0>	HA14_N	J16	N.C.	HB14_N	K35	N.C.
LA10_P	C14	OUTB_P<0>	HA14_P	J15	N.C.	HB14_P	K34	N.C.
LA11_N	H17	OUTA_N<7>	HA15_N	F17	N.C.	HB15_N	J34	N.C.
LA11_P	H16	OUTA_P<7>	HA15_P	F16	N.C.	HB15_P	J33	N.C.
LA12_N	G16	OUTB_N<7>	HA16_N	E16	N.C.	HB16_N	F35	N.C.
LA12_P	G15	OUTB_P<7>	HA16_P	E15	N.C.	HB16_P	F34	N.C.
LA13_N	D18	OUTA_N<6>	HA17_N_CC	K17	N.C.	HB17_N_CC	K38	N.C.
LA13_P	D17	OUTA_P<6>	HA17_P_CC	K16	N.C.	HB17_P_CC	K37	N.C.
LA14_N	C19	OUTB_N<6>	HA18_N	J19	N.C.	HB18_N	J37	N.C.
LA14_P	C18	OUTB_P<6>	HA18_P	J18	N.C.	HB18_P	J36	N.C.
LA15_N	H20	OUTA_N<5>	HA19_N	F20	N.C.	HB19_N	E34	N.C.
LA15_P	H19	OUTA_P<5>	HA19_P	F19	N.C.	HB19_P	E33	N.C.
LA16_N	G19	OUTB_N<5>	HA20_N	E19	N.C.	HB20_N	F38	N.C.
LA16_P	G18	OUTB_P<5>	HA20_P	E18	N.C.	HB20_P	F37	N.C.
LA17_N_CC	D21	DCO_N<2>	HA21_N	K20	N.C.	HB21_N	E37	N.C.
LA17_P_CC	D20	DCO_P<2>	HA21_P	K19	N.C.	HB21_P	E36	N.C.
LA18_N_CC	C23	FRAME_N<1>	HA22_N	J22	N.C.			
LA18_P_CC	C22	FRAME_P<1>	HA22_P	J21	N.C.			
LA19_N	H23	OUTA_N<4>	HA23_N	K23	N.C.			
LA19_P	H22	OUTA_P<4>	HA23_P	K22	N.C.			
LA20_N	G22	OUTB_N<4>						
LA20_P	G21	OUTB_P<4>						
LA21_N	H26	OUTA_N<11>						
LA21_P	H25	OUTA_P<11>						
LA22_N	G25	OUTB_N<11>						
LA22_P	G24	OUTB_P<11>						
LA23_N	D24	OUTA_N<10>						
LA23_P	D23	OUTA_P<10>						
LA24_N	H29	OUTB_N<10>						
LA24_P	H28	OUTB_P<10>						

LA25_N	G28	FRAME_N<2>						
LA25_P	G27	FRAME_P<2>						
LA26_N	D27	OUTA_N<9>						
LA26_P	D26	OUTA_P<9>						
LA27_N	C27	OUTB_N<9>						
LA27_P	C26	OUTB_P<9>						
LA28_N	H32	OUTA_N<8>						
LA28_P	H31	OUTA_P<8>						
LA29_N	G31	OUTB_N<8>						
LA29_P	G30	OUTB_P<8>						
LA30_N	H35	CTRL<1>						
LA30_P	H34	CTRL<0>						
LA31_N	G34	CTRL<3>						
LA31_P	G33	CTRL<2>						
LA32_N	H38	CTRL<5>				PG_C2M	D1	PG_C2M
LA32_P	H37	CTRL<4>				PG_M2C	F1	PG_M2C
LA33_N	G37	CTRL<7>				I2C_SCL	C30	I2C_SCL
LA33_P	G36	CTRL<6>				I2C_SDA	C31	I2C_SDA

Table 9: Signal description (FMC116/FMC112)

Signal	Group	Direction	I/O Standard	Description
DCO_N<3..0> DCO_P<3..0>	A/D	Output	LVDS	Digital clock output from the LTC2175. One pair per device.
OUTA_N<15..0> OUTA_P<15..0>	A/D	Output	LVDS	Output port A from the LTC2175. Four pairs per device.
OUTB_N<15..0> OUTB_P<15..0>	A/D	Output	LVDS	Output port B from the LTC2175. Four pairs per device.
FRAME_N<3..0> FRAME_P<3..0>	A/D	Output	LVDS	Frame output from the LTC2175. One pair per device.
CLK_TO_FPGA_N CLK_TO_FPGA_P	CLOCK	Output	LVDS	Spare clock output from the AD9517. May be used for debugging / monitoring purposes.
EXT_TRIGGER_N EXT_TRIGGER_P	TRIGGER	Output	LVDS	Representation of the signal connected to the external trigger input.
CTRL<0>	CONTROL	Input	CMOS VADJ	SPI clock connected to the CPLD
CTRL<1>	CONTROL	Input	CMOS VADJ	SPI chip select connected to the CPLD
CTRL<2>	CONTROL	Bidir	CMOS VADJ	SPI data in/out connected to the CPLD
CTRL<3>	CONTROL	Output	CMOS VADJ	Interrupt connected the CPLD (reserved for future use)
CTRL<6..4>	CONTROL	Bidir	CMOS VADJ	Reserved for future use
CTRL<7>	CONTROL	Input	CMOS VADJ	Connected to CPLD and external trigger output buffer
PG_C2M	STATUS	Input	LVTTL	Power good indicator from carrier to module
PG_M2C	STATUS	Output	LVTTL	Power good indicator from module to carrier
I2C_SCL	I2C	Input	LVTTL	I2C clock line
I2C_SDA	I2C	Bidir	LVTTL	I2C data line

Appendix B CPLD Register map

Bit nr.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Name	'0'	SYNC	CLKR	LDAC	DACR	Reserved	CLKSRC	

Table 10: Register CPLD_REG0 definition

Field	Description
CLKSRC	Selection of clock source
'00'	External clock
'01'	Internal clock, External Reference
'10'	Reserved, do not use
'11'	Internal clock, Internal Reference
DACR	Asynchronous DAC Clear
'0'	Normal operation, DAC output level can be set trough SPI.
'1'	All DAC output levels set to mid-scale. This bit is not self-clearing.
LDAC	Asynchronous DAC Update
'0'	Normal operation
'1'	Reserved for future use.
CLKR	Clock tree RESET
'0'	Normal operation
'1'	Resetting the clock tree is normally not required. This bit is not self-clearing.
SYNC	Clock tree SYNC
'0'	Normal operation
'1'	Synchronizing the clock tree is normally not required. This bit is not self-clearing.

Table 11 Register CPLD_REG0 description

Bit nr.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Name	Reserved			IRQ	VM	STATUS	LD	REFMON

Table 12: Register CPLD_REG2 definition (read)

Field		Description
REFMON		Reflect the status of the REFMON output of the AD9517
LD		Reflect the status of the LD output of the AD9517
STATUS		Reflect the status of the STATUS output of the AD9517
VM		Reflect the status of the INT# output of the ADT7411 (inverted)
	'0'	INT# is not asserted
	'1'	INT# is asserted, access to the ADT7411 through the I ² C bus is required to determine the source of the interrupt
IRQ		Logic function: NOT (REFMON AND LD AND STATUS AND INT#)
	'0'	All status signals indicate OK
	'1'	One or more status signals indicate ERROR

Table 13 Register CPLD_REG2 description (read)

Bit nr.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Name	Reserved			LED_SEL				

Table 14: Register CPLD_REG2 definition (write)

Field		Description
LED_SEL		Writing to this register determines which status signal is reflected on the LED.
	'XXXX1'	REFMON
	'XXX10'	LD
	'XX100'	STATUS
	'X1000'	VM
	'10000'	IRQ

Table 15 Register CPLD_REG2 description (write)